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# Large area color effects in polymer replica of black silicon

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## Introduction

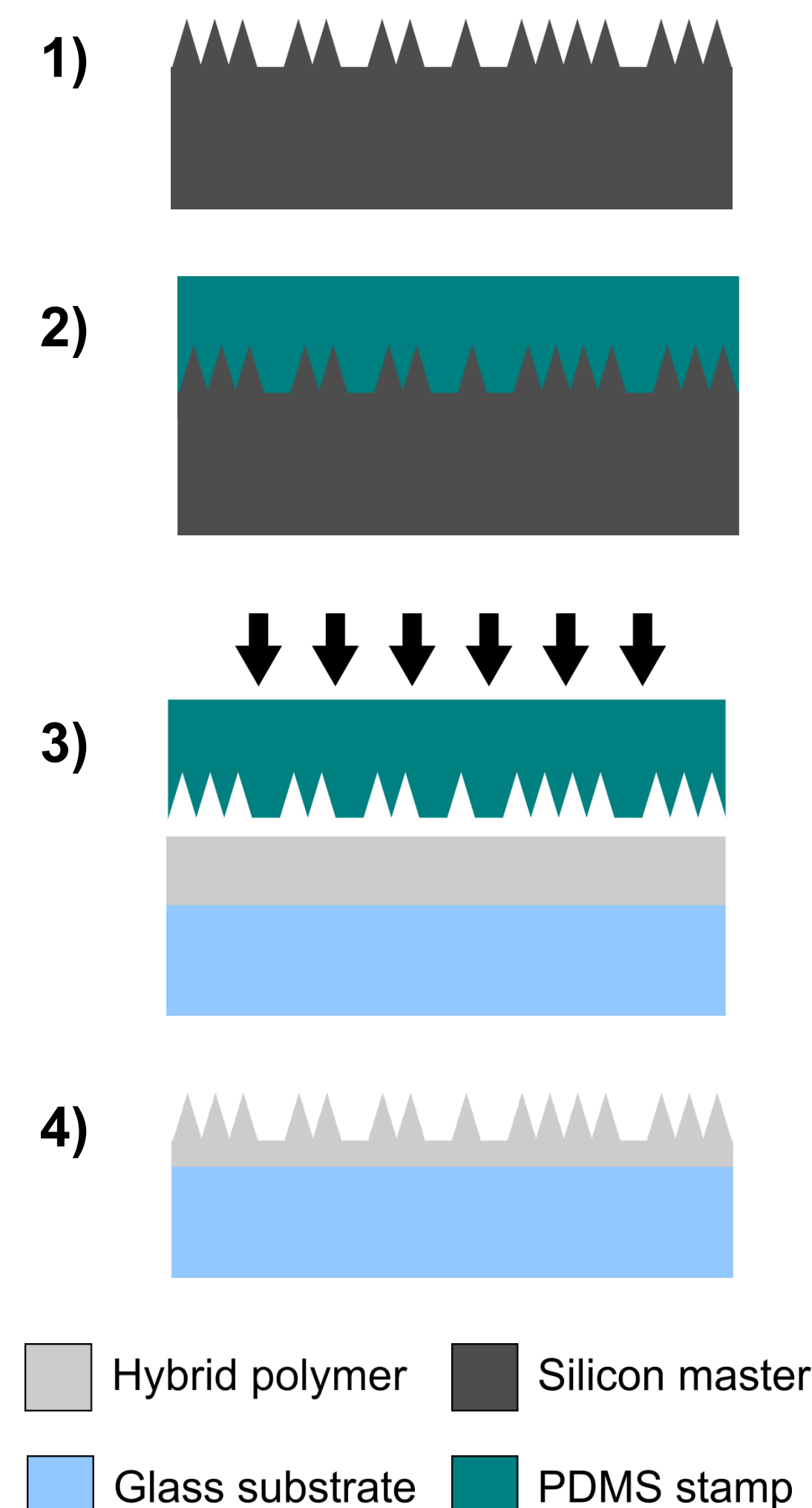
Replication of black silicon surface structures in polymers has previously been used for the purpose of antireflection. We utilize the scattering properties of the random rough surfaces fabricated in a black silicon process to create cheap large area color filters in an organic-inorganic hybrid polymer. Due to the tapered surface structures the method is suitable for large scale fabrication in thermoplastics with

methods such as hot embossing or injection molding.

The replication of black silicon structures to transparent materials can, through angle resolved transmission measurements, provide information on the scattering behavior of light on the black silicon surfaces.

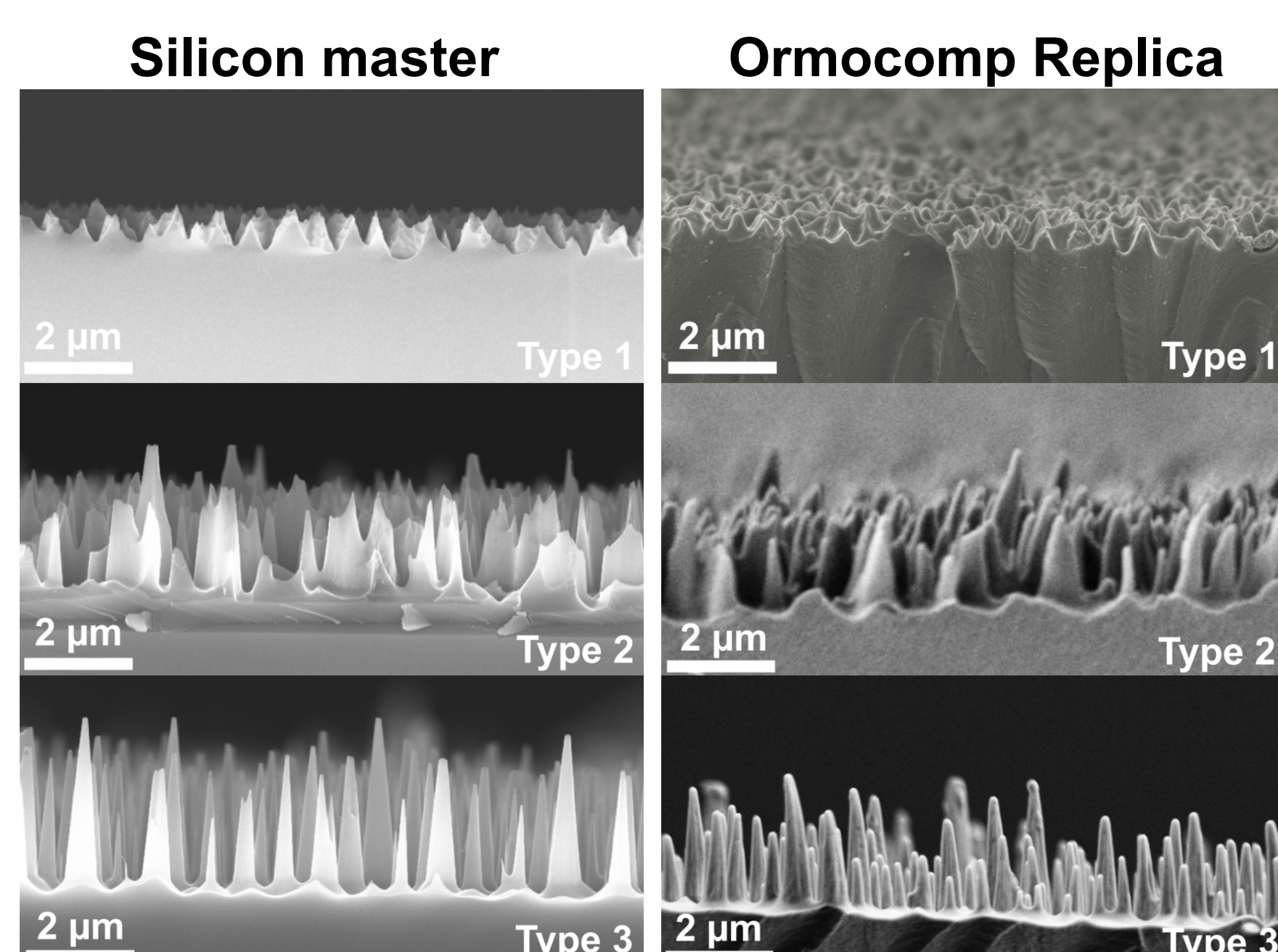
## Fabrication

- 1) A silicon master with black silicon is fabricated using reactive ion etching, patterned using photolithography, and FDTD coated for anti adhesion using molecular vapor deposition.
- 2) A PDMS stamp (Sylgard 184) is cast from the wafer.
- 3) Ormocomp is spin coated on a glass substrate followed by imprinting with the PDMS stamp in an UV-NIL process. The imprint is performed using a hydrostatic pressure of 10 bar.
- 4) The stamp is removed after UV-curing of the Ormocomp.

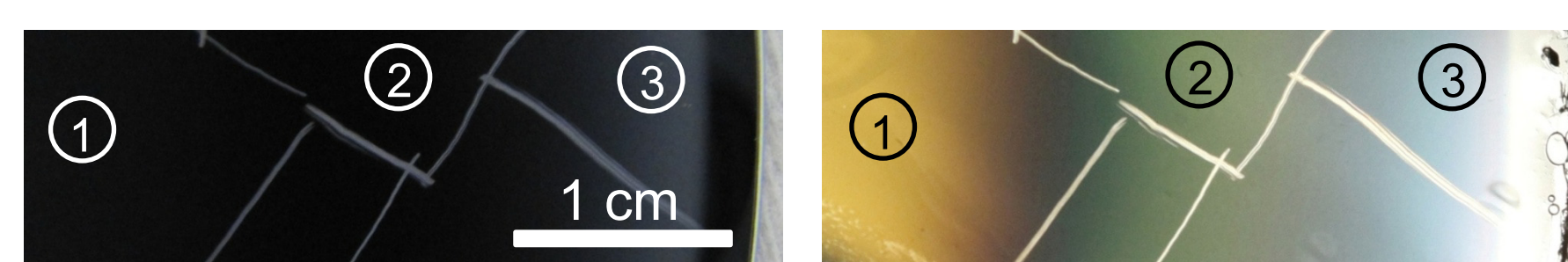


## Structural colors

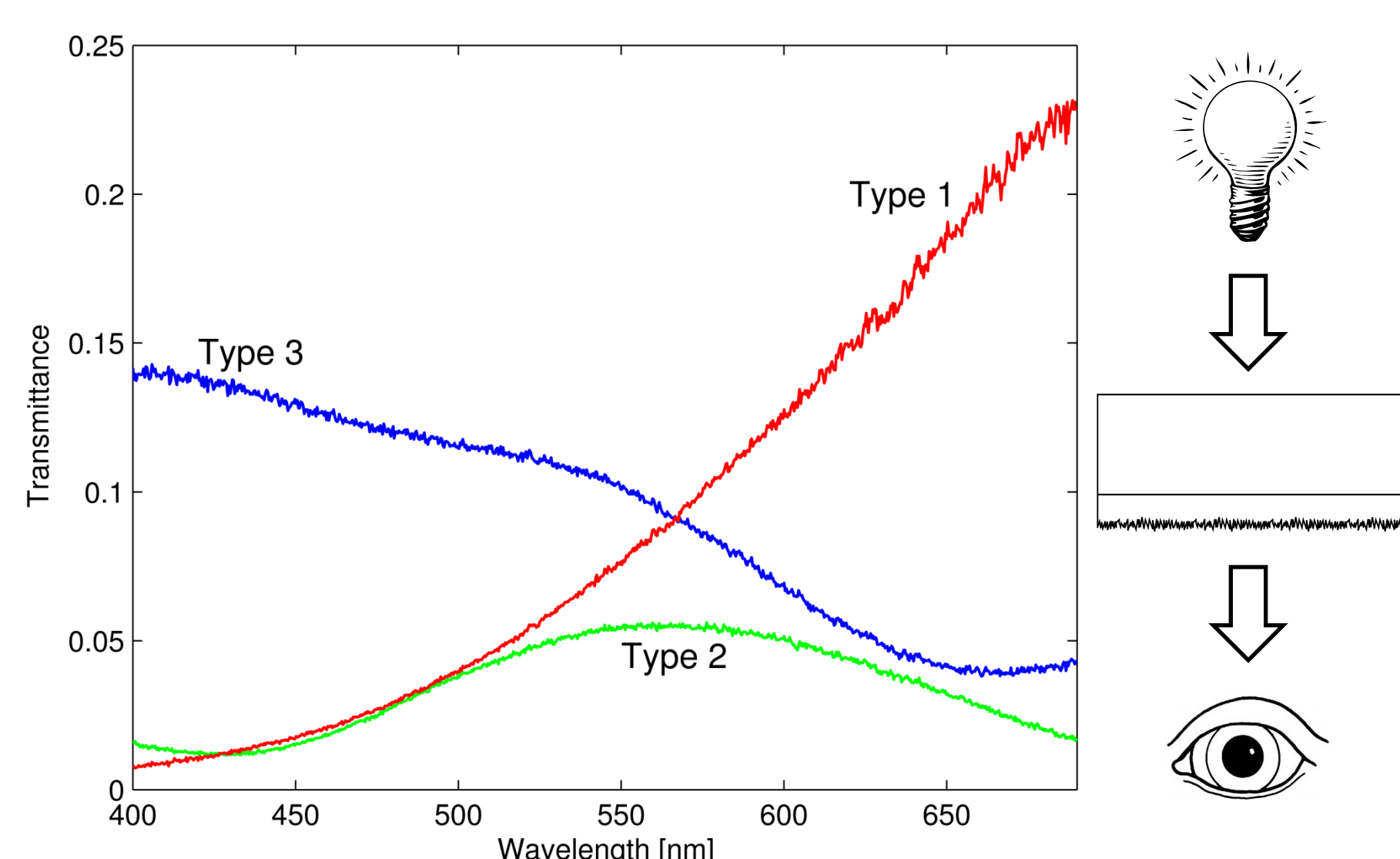
It is found that different colors arise from different types of surface structures. The SEM images below show the different types of silicon structures (left) and their replications in Ormocomp (right).



Photographs of silicon master (left) and white light transmitted through replica (right). The surface is scratched to identify different areas.

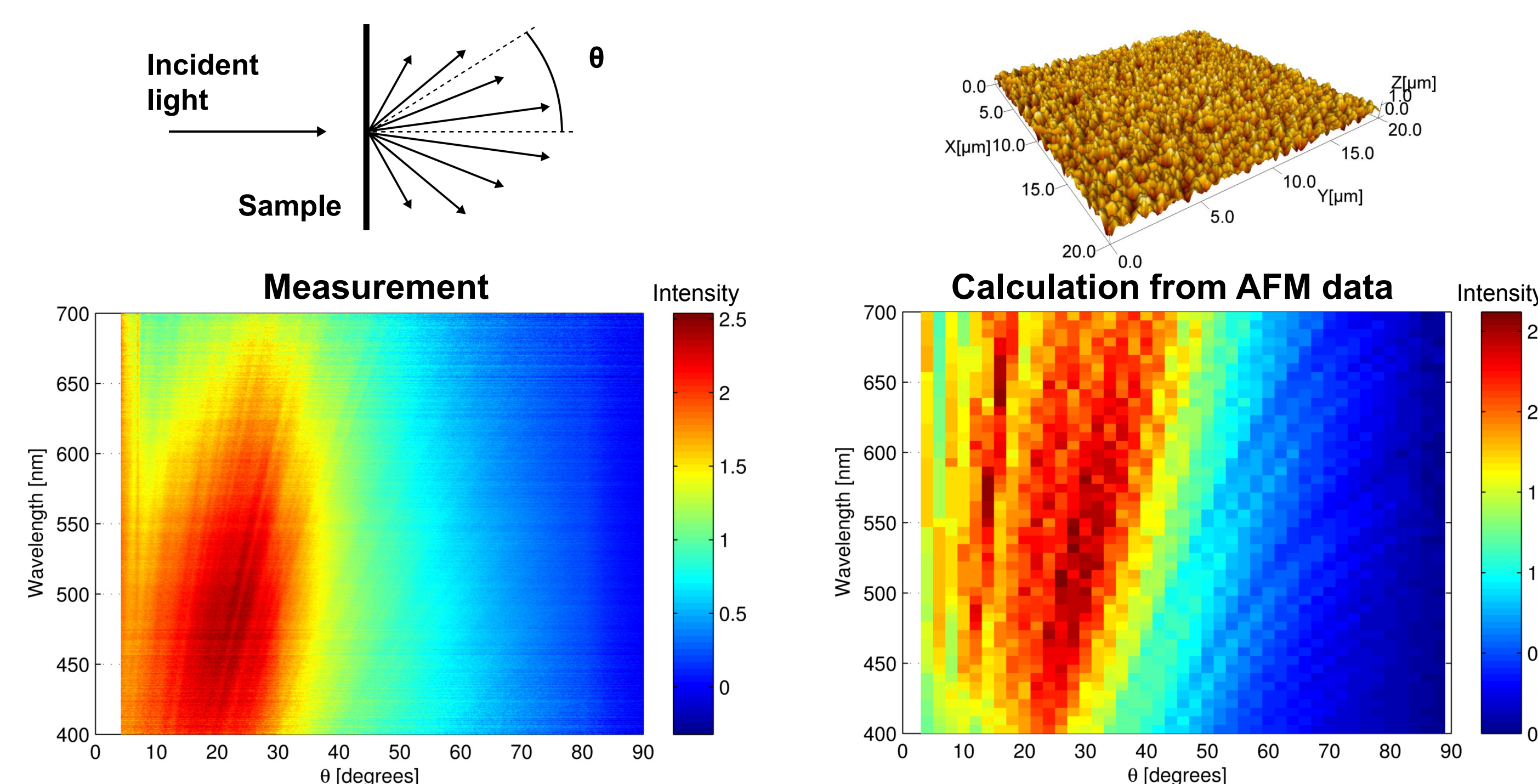


The transmission spectra of the three different types of structures.



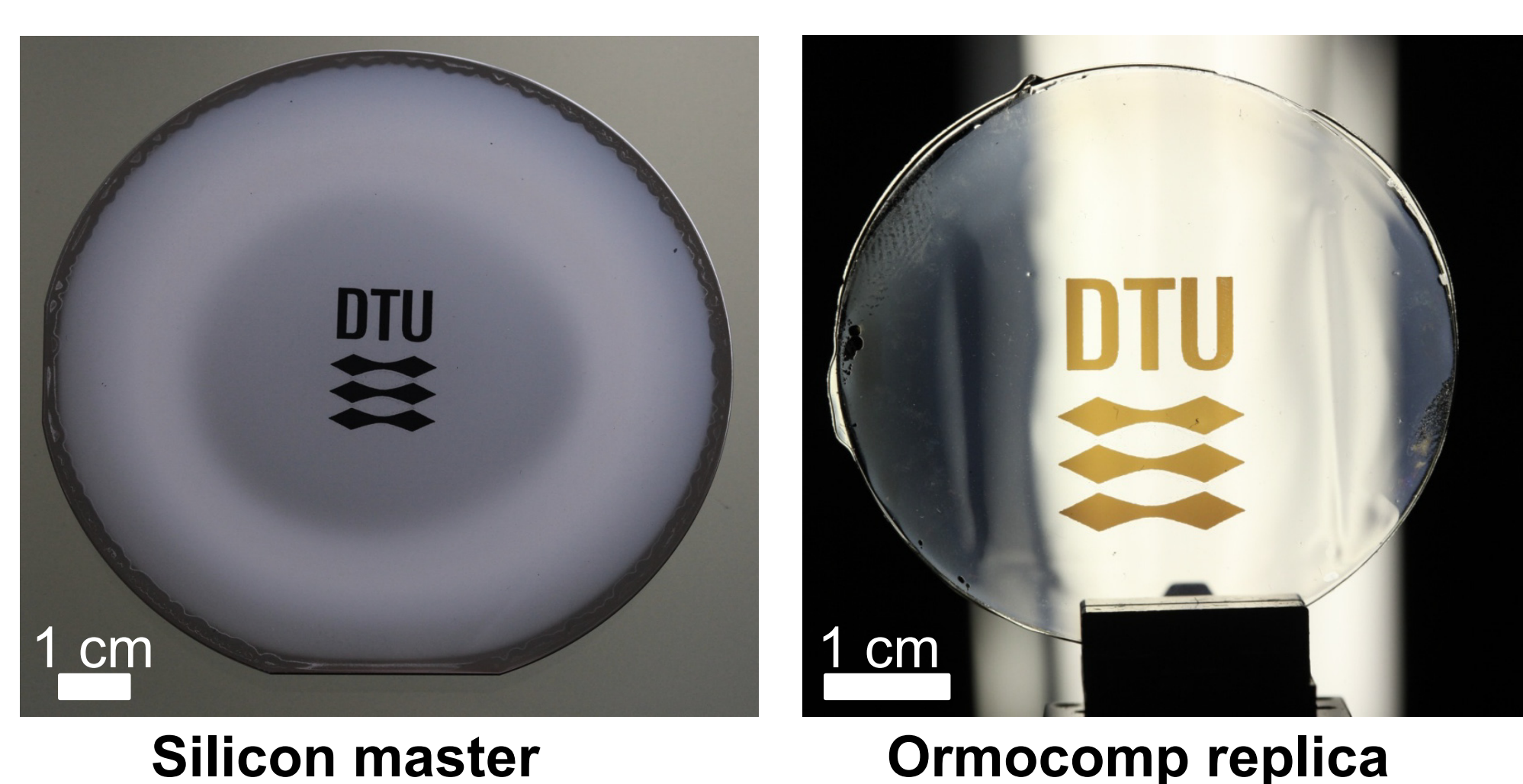
## Measurement and calculation

Angle resolved scattering measurements performed on structures of type 1 illustrate that short wavelengths are scattered to certain angles (left). The scattering is also calculated based on the diffraction on the surface topography measured by AFM (right).



## Patterned Structures

Using UV-lithography and reactive ion etching the black silicon surface can be patterned (left). In the replica, the pattern will appear as a colored design in directly transmitted light (right).



## Conclusion

Using UV-NIL with a PDMS stamp it is possible to replicate black silicon structures of different types to achieve structural color filters with different transmission spectra. The black silicon master can be patterned to fabricate large area colored designs. The colors appear due to wavelength dependent scattering, and the measured results can be calculated with good agreement, from an AFM image of the surface.

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